Remarks

The Office action mailed January 30, 2004, has been reviewed and carefully considered. The pending rejections are traversed for the reasons explained below.

U.S. Application Serial No. 09/780,184, U.S. Application Serial No. 09/780,079, and U.S. Application Serial No. 10/286,400, which are discussed by the examiner, will be listed on an Information Disclosure Statement filed shortly after this reply. It is noted that the U.S. Patent and Trademark Office was previously made aware of Serial No. 09/780,184 via telephone discussions on or around January 15, 2004, February 19, 2003, and November 1, 2002, between Stacey Slater (an attorney for applicants) and a succession of examiners to which this application has been assigned.

In section (V) of the Office action, the examiner indicates that the multiple groups of independent claims are not considered to be "patentably different or distinct." However, it is submitted that not all the pending claims stand or fall together in the context of patentability. In other words, the patentability of each independent claim does not depend upon the patentability of any other independent claim. However, the examiner was correct in not instituting a restriction requirement since the search and examination of the entire application was made without a serious burden (see MPEP §803).

In section (VI) of the Office action, the examiner states that "[i]t is found that no embodiment or combined embodiments are new and patentably different and distinct from the teachings and suggestions in the submitted references on the record." The remaining portion of the Office action then cites to specific documents and statutory basis for specific rejections. Accordingly, applicants are responding to these specific rejections rather than the general statements in section (VI) of the Office action. Applicants' response is consistent with the requirement that an Office action "should designate the statutory basis for any ground of rejection by express reference to section of 35 U.S.C. in the opening sentence of each ground of rejection." MPEP §707.07(d).

"Same Invention" Double Patenting Rejection over Serial No. 09/780,184

All the pending claims have been rejected for "same invention" double patenting over U.S. Application Serial No. 09/780,184. A double patenting rejection over U.S. Application Serial No. 09/780,184 is legally incorrect since there is no common inventor or assignee shared by the 09/780,184 application and the present application. As stated in the MPEP at §804, "[b]efore consideration can be given to the issue of double patenting, there must be some common relationship of inventorship and/or ownership of two or more patents or applications" (see also the charts set forth in MPEP §804). In other words, double patenting is only appropriate if there is at least one common inventor or assignee. The 09/780,184 application is not assigned to QuestAir Technologies. QuestAir Technologies is the assignee of the present application. The 09/780,184 application lists Craig Gittleman, William Pettit and Gerald Voecks as inventors. None of these individuals are inventors in the present application. Hence, the pending double patenting rejection over the 09/780,184 application must be withdrawn.

Applicants also note that the Office action indicates that the claims "are provisionally rejected under 35 U.S.C. §101 as claiming the same invention as that of the pending claims of copending Application No. 09/780,184 as stated by applicants." However, an amendment was filed on December 24, 2003 in the 09/780,184 application that amended the claims so that they are quite different from those pending in the present application (copy of the publicly available amendment is appended as Exhibit A). Note that PAIR as of May 25, 2004, indicates that no further amendments have been filed, and that a non-final rejection was mailed on March 25, 2004.

The independent claims (claims 20 and 46) pending as of December 24, 2003 in the 09/780,184 application both recite a system that includes a water gas shift reactor that includes "a second adsorbent adapted to adsorb carbon monoxide" (claim 20) or "an adsorbent that is a first adsorbent adapted to adsorb the carbon monoxide" (claim 46). None of the pending claims in the present application are directed to a system that includes a water gas shift reactor, wherein the water gas shift reactor itself includes a carbon monoxide adsorbent. Thus, the 09/780,184 application and the pending application do not claim the same invention.

Obviousness-Type Double Patenting Rejection over Serial No. 09/780,079

All the pending claims have been rejected for obviousness-type double patenting over U.S. Application Serial No. 09/780,079. The 09/780,079 application has now issued as U.S. Patent No. 6,692,545 (copy appended as Exhibit B). In any event, a double patenting rejection over U.S. Application Serial No. 09/780,079 or U.S. Patent No. 6,692,545 is legally incorrect since there is no common inventor or assignee shared by the 09/780,079 application and the present application. The 09/780,079 application is assigned to General Motors Corporation rather than QuestAir Technologies. QuestAir Technologies is the assignee of the present application. The 09/780,079 application lists Craig Gittleman and Ramesh Gupta as inventors. None of these individuals are inventors in the present application. Hence, the pending obviousness-type double patenting rejection over the 09/780,079 application (now U.S. Patent No. 6,692,545) must be withdrawn.

It is also noted that the claims in the '545 patent are quite different from those pending in the present application. For example, independent claims 1 and 21 are directed towards a system that includes a wheel, wherein wheel includes a catalyst for performing a water gas shift reaction and an adsorbent for adsorbing carbon dioxide.

"Same Invention" Double Patenting Rejection over Serial No. 10/286,400

All the pending claims have rejected for "same invention" double patenting over U.S. Application Serial No. 10/286,400. The 10/286,400 application is a continuation of the present application. A second preliminary amendment was filed in the 10/286,400 application on October 16, 2003 (copy attached as Exhibit C). A "same invention" double patenting rejection requires that the two applications claim the "identical subject matter" (see MPEP §804 (II)(A)). As explained below, the 10/286,400 application and the present application do not claim the identical subject matter.

Independent system claim 1 (and dependent claims 2-24, 30, 31, 71-77, 115, 116) of the '400 application does not recite a hydrogen gas delivery system or a hydrogen gas separation device. All of the pending system claims in the present application include a hydrogen gas delivery system or a hydrogen gas separation device.

Claims 25-28 and 38 of the '400 application recite a system that includes a hydrogen gas delivery system, but the claimed system also includes a rotary PSA for an oxygen gas delivery system (see claim 1 and 38). None of the pending system claims in the present application recite a rotary PSA for an oxygen gas delivery system.

A third preliminary amendment will be filed in the '400 application concurrently with this reply to amend claim 32 to incorporate the subject matter of claim 45, which is not claimed in the present application. Claims 37, 47-50, 113 and 114 of the '400 application depend from amended claim 32.

Independent method claim 54 (and dependent claims 55-60) of the '400 application includes supplying a gas feed to a rotary PSA to produce a stream enriched in oxygen. None of the pending method claims in the present application recite supplying a gas feed to a rotary PSA to produce a stream enriched in oxygen.

Independent method claim 61 (and dependent claims 62-68) of the '400 application recites a process that includes supplying a gaseous stream enriched in oxygen gas to the cathode gas inlet. None of the pending method claims in the present application recite supplying a gaseous stream enriched in oxygen gas to the cathode gas inlet.

Independent system claim 69 (and dependent claim 70) of the '400 application recites a system that includes an oxygen PSA to enrich oxygen and remove CO_2 from an atmospheric air feed. None of the pending system claims in the present application recite an oxygen PSA to enrich oxygen and remove CO_2 from an atmospheric air feed.

Independent system claim 78 (and dependent claims 79-81, 109 and 110) of the '400 application differs from claim 82 of the present application since claim 82 includes an adsorbent that preferentially adsorbs at least one carbon oxide.

Independent system claim 82 (and dependent claims 83-87) of the '400 application differs from claim 92 of the present application since claim 92 includes an adsorbent that preferentially adsorbs at least one carbon oxide.

Independent system claim 88 (and dependent claims 89-94) of the '400 application differs from claim 101 of the present application since claim 101 includes an adsorbent that preferentially adsorbs at least carbon monoxide.

There are no pending claims in the present application that are similar to claims 95-103, 111 and 112 of the '400 application.

Independent system claim 104 of the '400 application includes an oxygen gas delivery system that includes at least one air compressor; a feature that is not recited in any pending claims in the present application.

Independent system claim 105 (and dependent claims 106-108) of the '400 application includes a gas turbine system; a feature that is not recited in any pending claims in the present application.

Accordingly, the pending "same invention" double patenting rejection over Ser. No. 10/286,400 should be withdrawn.

35 U.S.C. §103 Rejection

All the pending claims have been rejected under 35 U.S.C. §103 over JA-62278770-A1 (Shiro) combined with CA 2,109,055 and/or CA 2,016,045. An English translation of Shiro is attached as Exhibit D. A close examination of Shiro and the secondary Canadian patent applications reveals that the purported combination of these references would not have resulted in the presently claimed subject matter recited in each of the independent claims. Each independent claim is explored below in more detail.

Claim 33

Claim 33 recites a system that includes a hydrogen gas delivery system coupled to an anode inlet of a fuel cell, wherein the hydrogen gas delivery system includes a **rotary** pressure swing adsorption (PSA) system for enriching hydrogen in a gaseous feed. The system of Shiro does not specify any particular type of PSA, much less a **rotary** PSA. CA 2,016,045 similarly fails to disclose a **rotary** PSA. The specific system described in CA 2,109,055 at page 32, line 16 – page 33, line 32, which was cited by the examiner also does not disclose a **rotary** PSA. The “BACKGROUND ART” section of CA 2,109,055 does refer to U.S. Patent No. 4,452,612 (Mattia) (included in the Information Disclosure Statement that will be filed shortly after this reply) as “using a rotary adsorbent bed assembly whose multiple elements sweep past fixed ports for feed admission, product delivery and pressure equalization.” However, there is nothing in CA 2,109,055 (or Shiro or CA 2,016,045 for that matter) that would have prompted a person of

ordinary skill in the art to employ a **rotary** PSA as the PSA in any of the prior art systems. Accordingly, the pending §103 rejection of claim 33 (and claims 34-36, 39, 40, 42-44, 46, 51 and 52 that depend therefrom) must be reconsidered and withdrawn.

Claim 82

Claim 82 recites a system that includes a hydrogen gas delivery system coupled to a fuel cell for delivering hydrogen to the fuel cell, wherein the hydrogen gas delivery system includes a **rotary** pressure swing adsorption (PSA) that includes an adsorbent that preferentially adsorbs at least one carbon oxide. As discussed above in connection with claim 33, the relied-upon prior art does not describe or teach a system that includes a rotary PSA. For this reason alone, the pending rejection of claim 82 must be withdrawn.

Claim 82 also states that the rotary PSA includes an adsorbent that preferentially adsorbs at least one carbon oxide. In the Shiro system CO_2 is absorbed in an absorption tower 1 (see page 4 of the translation). The offgas RH_2 containing gases other than H_2 is introduced into a series of PSA units resulting in a gas that includes 89.5% H_2, 1.1% CO, 0.4% CO_2 and 9% N_2 (see page 9 of the translation). Shiro fails to mention any specific types of adsorbents for the PSA units, much less an adsorbent that preferentially adsorbs at least one carbon oxide. In addition, there would have been no motivation to substitute the PSA systems disclosed in CA 2,016,045 and CA 2,109,055 for the PSA units in the Shiro system.

The PSA system described at page 63, line 16 - page 64, line 12, in CA 2,016,045 mentions the removal of CO_2. However, the Shiro system employs an absorption tower for removing CO_2. There is no suggestion in any of the relied-upon art to substitute a PSA for the absorption tower.

There is no mention in CA 2,109,055 that the PSA system described at page 32, line 16 - page 33, line 32, could be used in association with a fuel cell. The examiner has offered no reasoning why one of ordinary skill in the art would have been motivated to substitute the PSA system of CA 2,109,055 for the PSA system of Shiro. In the absence of such motivation, the obviousness rejection cannot be sustained.

Claims 92 and 101

Claims 92 and 101 recite a system that includes a "hydrogen gas separation device receiving a recycle gas from the fuel cell anode outlet and a hydrogen feed gas from a hydrogen gas generating system." Shiro, CA 2,109,055, or CA 2,016,045 do not disclose a system that includes fuel cell recycle stream as recited in claim 92. Since this feature is not even hinted at in the relied-upon prior art, the pending obviousness rejection of claim 92 must be withdrawn.

Claim 104

Claim 104 recites a process that includes introducing a hydrogen-containing feed gas into a rotary PSA. As discussed above in connection with claim 33, the relied-upon prior art does not describe or teach a process that includes a rotary PSA. For this reason alone, the pending rejection of claim 104 must be withdrawn.

In addition, the process of claim 104 includes "generating a hydrogen-containing feed gas via reforming or partial oxidation." Shiro and CA 2,016,045 are utterly silent with respect to any reforming or partial oxidation processes. CA 2,109,055 does mention steam reforming and partial oxidation, but there is nothing in the relied-upon prior art that would have suggested including reforming or partial oxidation the Shiro system.

Claims 113 and 114

Claims 113 and 114 recite a process that includes adsorbing at least one contaminant from a first hydrogen-containing feed gas stream, adsorbing at least one contaminant from a second hydrogen-containing feed gas stream, and then introducing both of the resulting purified streams into a fuel. Neither Shiro, nor CA 2,109,055, nor CA 2,016,045 discloses a process that involves introducing two purified hydrogen streams into a fuel cell. Since this feature cannot be gleaned from the relied-upon prior art, the pending obviousness rejection of claims 113 and 114 must be withdrawn.

It is respectfully submitted that the application is in condition for allowance. Should there be any questions regarding this application, Examiner Le is invited to contact the undersigned attorney at the telephone number shown below.

Respectfully submitted,

KLARQUIST SPARKMAN, LLP

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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.:	09/780,184
Filing Date:	February 9, 2001
Applicant:	Craig S. Gittleman et al.
Group Art Unit:	1746
Examiner:	Basia Anna Ridley
Title:	CARBON MONOXIDE ADSORPTION FOR CARBON MONOXIDE CLEAN-UP IN A FUEL CELL SYSTEM
Attorney Docket:	8540G-000038

Mail Stop Non-Fee Amendment
Director of The United States Patent and Trademark Office
P.O. Box 1450
Alexandria, Virginia 22313-1450

REVISED AMENDMENT

Sir:

In response to the Notice of Non-Compliance Amendment (37 CFR 1.121) mailed December 17, 2003, for which response is being filed by the due date of January 17, 2004, please except this Revised Amendment to the Office Action mailed August 27, 2003, for which response was filed by its due date of November 27, 2003. *Please note that the required revisions herein relate to the inclusion of withdrawn claims (Claims 19 and 31-45) that were mistakenly omitted from our original Amendment.* Please amend the application as follows and consider the remarks set forth below.

Amendments to the Specification begin on page 2 of this paper.
Amendm nts to th Claims begin on page 3 of this paper.
Am ndm nts to the Drawings begin on page 13 of this paper.
Remarks begin on page 14 of this paper.

EXHIBIT
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12-24-03

1746
Image

Please type a plus sign (+) inside this box → +

HDP/SB/21 based on PTO/SB/21 (08-00)

TRANSMITTAL FORM

(to be used for all correspondence after initial filing)

Application Number	09/780,184
Filing Dat	February 9, 2001
First Nam d Inventor	Craig S. Gittleman et al.
Group Art Unit	1746
Examiner Name	Basia Anna Ridley
Attorney Docket Number	8540G-000038
Total Number of Pages in This Submission	

ENCLOSURES *(check all that apply)*

- ☐ Fee Transmittal Form
  - ☐ Fee Attached
- ☒ Amendment / Response
  - ☐ After Final
  - ☐ Affidavits/declaration(s)
- ☐ Extension of Time Request
- ☐ Express Abandonment Request
- ☐ Information Disclosure Statement
- ☐ Certified Copy of Priority Document(s)
- ☐ Response to Missing Parts/ Incomplete Application
  - ☐ Response to Missing Parts under 37 CFR 1.52 or 1.53
- ☐ Assignment Papers *(for an Application)*
- ☐ Drawing(s)
- ☐ Licensing-related Papers
- ☐ Petition
- ☐ Petition to Convert to a Provisional Application
- ☐ Power of Attorney, Revocation Change of Correspondence Address
- ☐ Terminal Disclaimer
- ☐ Request for Refund
- ☐ CD, Number of CD(s) ____
- ☐ After Allowance Communication to Group
- ☐ Appeal Communication to Board of Appeals and Interferences
- ☐ Appeal Communication to Group *(Appeal Notice, Brief, Reply Brief)*
- ☐ Proprietary Information
- ☐ Status Letter
- ☒ Other Enclosure(s) *(please identify below)*:
  return receipt postcard

Remarks	**The Commissioner is hereby authorized to charge any additional fees that may be required under 37 CFR 1.16 or 1.17 to Deposit Account No. 07-0960. A duplicate copy of this sheet is enclosed.**

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm or Individual name	Harness, Dickey & Pierce, P.L.C.	Attorney Name Linda M. Deschere	Reg. No. 34,811
Signature	[signature]		
Date	December 24 2003		

CERTIFICATE OF MAILING/TRANSMISSION

I hereby certify that this correspondence is being deposited with the United States Postal Service as express mail in an envelope addressed to: Director of the U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450, or facsimile transmitted to the U.S. Patent and Trademark Office on the date indicated below.

Typed or printed name	Linda M. Deschere	Express Mail Label No.	EV 406 075 630 US (12/24/2003)
Signature	[signature]	Date	Dec 24 2003

AMENDMENTS TO THE SPECIFICATION

Please replace the paragraph found on Page 12, Lines 4-23 with the following paragraph rewritten in amendment format:

Conventional pressure swing adsorption (PSA) systems are very large and consist of a minimum of two separate adsorption vessels complete with numerous valves and manifolds. In a two-vessel system, one vessel would be in the adsorption mode and the second vessel would be in various stages of depressurization or blowdown, purge, and pressurization. Many commercial hydrogen PSA cycles use four beds, with one bed in the production stage at any given time, and the other three beds in various stages of equalization, blowdown, purge, and pressurization. See, for example U.S. Patent No. ~~3,453,418~~ 5,646,305 issued to Wagner; and U.S. Patent No. 3,564,816 issued to Batta, each of the disclosures of which is incorporated herein by reference in its entirety. Also, some commercial hydrogen PSA cycles use twelve beds, with four beds in the production stage at any given time, and the other eight beds in various stages of equalization, blowdown, purge, and pressurization. See for example U.S. Patent No. ~~3,846,849~~ 5,958,109 issued to Fuderer *et al.*, the disclosure of which is incorporated herein by reference in its entirety. These PSA cycle stages are described in detail below. It is well known that PSA systems with more than two vessels exhibit higher hydrogen recoveries and reduced power by incorporating pressure equalization steps. These multiple, staged fixed bed PSA systems, however, contain complex valve arrangements and are non-continuous due to the cycling of these valves.

AMENDMENTS TO THE CLAIMS

The following listing of claims will replace all prior versions and listings of claims in the application.

Listing Of Claims

1. (cancelled)

2. (currently amended) The system as defined in claim [[1]] <u>47</u> wherein the vessel is a pressure swing adsorber.

3. (original) The system as defined in claim 2 wherein the pressure swing adsorber comprises multiple, staged fixed beds.

4. (original) The system as defined in claim 2 wherein the pressure swing adsorber is a rotating vessel.

5. (original) The system as defined in claim 4 wherein the rotating vessel comprises:

   an adsorption region;

   a depressurization region;

   a purge region; and

   a pressurization region.

6. (original) The system as defined in claim 4 wherein the rotating vessel comprises two fixed valve faces.

7. (currently amended) The system as defined in claim [[1]] <u>46</u> which is a fuel cell system.

8. (currently amended) The system as defined in claim [[1]] <u>47</u> wherein <u>at least one of</u> the <u>first and second</u> adsorbent is selected from the group consisting of 5A zeolite, 13X zeolite, and mixtures thereof.

9. (currently amended) The system as defined in claim [[1]] <u>47</u> wherein <u>at least one of</u> the <u>first and second</u> adsorbent is selected from the group consisting of: oxides or salts of copper impregnated or exchanged on activated carbon, alumina, and zeolites; oxides or salts of silver impregnated or exchanged on activated carbon, alumina, and zeolites; oxides or salts of tin impregnated or exchanged on activated carbon, alumina, and zeolites; and mixtures thereof.

10. (currently amended) The system as defined in claim [[9]] <u>47</u> wherein, upstream of the <u>second</u> carbon monoxide adsorbent, the vessel comprises a layer of a desiccant material.

11. (original) The system as defined in claim 10 wherein the desiccant material is selected from the group consisting of zeolite molecular sieves, activated alumina, silica gels, and mixtures thereof.

12-13. (cancelled)

14. (currently amended) The system of claim [[12]] 46 wherein the water gas shift reactor is a high temperature water gas shift reactor.

15. (currently amended) The system as defined in claim [[12]] 46 wherein the ~~second~~ first adsorbent is adapted to adsorb carbon monoxide at low temperatures and is adapted to desorb carbon monoxide at high temperatures.

16. (currently amended) The system as defined in claim [[1]] 47 which further comprises an expander downstream of the vessel, and wherein the expander provides a purge gas to be fed back into the vessel.

17. (original) The system as defined in claim 16 which further comprises a fuel cell stack having an anode exhaust, the fuel cell stack disposed between the vessel and the expander, and wherein the expander expands the anode exhaust, the expanded anode exhaust providing the purge gas to be fed back into the vessel.

18. (original) The system as defined in claim 16 wherein the vessel is a rotating vessel, and wherein the expander is an isothermal expander adapted to provide electrical power for driving the rotating vessel.

19. (withdrawn) The system as defined in claim 2 wherein the hydrogen fuel cell system includes a low pressure steam stream, and wherein the steam stream provides a purge gas to be fed into the vessel.

20. (original) A system which comprises a first reactor which produces a hydrogen-rich gas stream containing CO, and an apparatus for removing the carbon monoxide (CO) from the hydrogen-rich gas stream, the apparatus comprising:

a rotating vessel housing a first adsorbent adapted to adsorb the carbon monoxide, wherein the rotating vessel is a pressure swing adsorber and comprises two fixed valve faces, and wherein the rotating vessel further comprises:

an adsorption region;

a depressurization region;

a purge region; and

a pressurization region; and

a second reactor which is a water gas shift reactor disposed between the first reactor and the vessel, wherein the water gas shift reactor includes a second adsorbent adapted to adsorb carbon monoxide, wherein the second adsorbent is adapted to adsorb carbon monoxide at low temperatures and is adapted to desorb carbon monoxide at high temperatures.

21. (original) The system as defined in claim 20 wherein the system further comprises an expander downstream of the vessel, and wherein the expander provides a purge gas to be fed back into the vessel.

22. (original) The system as defined in claim 21 wherein the system is a hydrogen fuel cell system further comprising a fuel cell stack having an anode exhaust, the fuel cell stack disposed between the vessel and the expander, and wherein the expander expands the anode exhaust, the expanded anode exhaust providing the purge gas to be fed back into the vessel.

23. (original) The system as defined in claim 21 wherein the expander is an isothermal expander adapted to provide electrical power for driving the rotating vessel.

24. (original) The system as defined in claim 20 wherein the system includes a low pressure steam stream, and wherein the steam stream provides a purge gas to be fed into the vessel.

25. (original) The system as defined in claim 20 wherein the first adsorbent is further adapted to adsorb at least one of carbon dioxide and water from the hydrogen-rich gas stream.

26. (original) The system as defined in claim 25 wherein the first adsorbent is selected from the group consisting of 5A zeolite, 13X zeolite, and mixtures thereof.

27. (original) The system as defined in claim 20 wherein the adsorbent is selected from the group consisting of oxides or salts of copper impregnated or exchanged on activated carbon, alumina, and zeolites; oxides or salts of silver impregnated or exchanged on activated carbon, alumina, and zeolites; oxides or salts of tin impregnated or exchanged on activated carbon, alumina, and zeolites; and mixtures thereof.

28. (original) The system as defined in claim 27 wherein, upstream of the first carbon monoxide adsorbent, the vessel comprises a layer of a desiccant material selected from the group consisting of zeolite molecular sieves, activated alumina, silica gels, and mixtures thereof.

29. (original) The system as defined in claim 7 wherein a preferential oxidizer (PROX) is eliminated from the hydrogen fuel cell system.

30. (original) The system as defined in claim 22 wherein a preferential oxidizer (PROX) is eliminated from the hydrogen fuel cell system.

31. (withdrawn) A method for removing carbon monoxide (CO) from a hydrogen-rich gas stream produced in a first reactor, the method comprising the step of passing the hydrogen-rich gas stream through a vessel which houses an adsorbent adapted to adsorb the carbon monoxide.

32. (withdrawn) The method as defined in claim 31 wherein the vessel is a rotating pressure swing adsorber.

33. (withdrawn) The method as defined in claim 32, further comprising the steps of:

pressurizing the vessel before the passing of the hydrogen-rich gas stream through the vessel;

depressurizing the vessel after the passing of the hydrogen-rich gas stream through the vessel; and

purging the vessel with a gas having a low carbon monoxide concentration.

34. (withdrawn) The method as defined in claim 31 wherein the hydrogen-rich gas stream is not passed through a preferential oxidizer (PROX).

35. (withdrawn) The method as defined in claim 31 wherein the adsorbent is a first adsorbent, and wherein the method further comprises the step of passing the hydrogen-rich gas stream through a second reactor which is a water gas shift reactor disposed between the first reactor and the vessel.

36. (withdrawn) The method of claim 35 wherein the water gas shift reactor includes a second adsorbent adapted to adsorb carbon monoxide.

37. (withdrawn) The method as defined in claim 36 wherein the second adsorbent is adapted to adsorb carbon monoxide at low temperatures and is adapted to desorb carbon monoxide at high temperatures.

38. (withdrawn) The method of claim 31 which in start-up mode comprises forming said hydrogen-rich stream by reacting a hydrocarbon fuel and air in the first reactor.

39. (withdrawn) The method of claim 38 which further includes a second reactor which is a water gas shift reactor disposed between the first reactor and the vessel.

40. (withdrawn) The method of claim 38 wherein after the start-up mode, steam is reacted along with the hydrocarbon fuel and air in the first reactor.

41. (withdrawn) A method for removing carbon monoxide from a hydrogen-rich gas stream produced in a first reactor, the method comprising the steps of:

passing the hydrogen-rich gas stream through a vessel which houses an adsorbent adapted to adsorb the carbon monoxide to provide a reduced CO content, wherein the vessel is a rotating pressure swing adsorber;

pressurizing the vessel before the passing of the hydrogen-rich gas stream through the vessel;

depressurizing the vessel after the passing of the hydrogen-rich gas stream through the vessel; and

purging the vessel with a gas having a low carbon monoxide concentration.

42. (withdrawn) The method as defined in claim 41 wherein the adsorbent is a first adsorbent, and wherein the method further comprises the step of passing the hydrogen-rich gas stream through a second reactor which is a high temperature water gas shift reactor disposed between the first reactor and the vessel, wherein the water gas shift reactor includes a second adsorbent adapted to adsorb carbon monoxide.

43. (withdrawn) The method as defined in claim 42 wherein the second adsorbent is adapted to adsorb carbon monoxide at low temperatures and is adapted to desorb carbon monoxide at high temperatures.

44. (withdrawn) The method as defined in claim 41 wherein the hydrogen-rich gas stream is not passed through a preferential oxidizer (PROX).

45. (withdrawn) The method of claim 41 which is conducted in a fuel cell system having a fuel cell stack, and wherein the hydrogen-rich gas stream having the reduced CO content is reacted in the fuel cell stack.

46. (new) A system which comprises:

a first reactor which produces a hydrogen-containing gas stream containing carbon monoxide; and

a second reactor, which is a water-gas shift reactor disposed downstream of said first reactor, said water-gas shift reactor having an adsorbent that is a first adsorbent adapted to adsorb the carbon monoxide.

47. (new) The system of claim 46 comprising a vessel downstream of said water-gas shift reactor, said vessel housing a second adsorbent adapted to adsorb the carbon monoxide.

AMENDMENTS TO THE DRAWINGS

The attached "Replacement Sheets" of drawings include changes to Figures 1 and 2. The attached "Replacement Sheets," which include Figures 1 and 2, replace the original sheets including Figures 1 and 2.

Attachment: 2x Replacement Sheet

REMARKS

The application was originally filed with 45 Claims. Claims 2-11, 14-18, 20-30, and 46-47 are now pending in the application. Claims 2, 7-10 and 14-16 have been amended; Claims 1, 12 and 13 have been cancelled; Claims 46 and 47 are new; and, as a result of multiple restrictions/election requirements, Claims 19 and 31-45 were withdrawn from consideration.

Claims 20-28 and 30 are allowable; Claims 13 and 15 are objected to; and Claims 1-12, 14, 16-18, and 29 are rejected.

INFORMATION DISCLOSURE STATEMENT

The Office Action makes reference to an Information Disclosure Statement filed as Paper 3 on October 15, 2002. Applicants are not aware of such IDS having been filed by Applicants; however, Applicants are aware of a third-party submission having been filed on or about October 14, 2002 and assumes that the Examiner has confused such third-party submission with an IDS.

Clarification on this point is respectfully requested.

SPECIFICATION

The specification was objected to on the basis of certain informalities as to patent numbers referenced therein by way of background, on Page 12, Lines 11-18, which has now been corrected.

<u>DRAWINGS</u>

Drawings were objected to on the basis that reference characters 1-10 in Figure 1 and in Figure 2 are lacking lead lines and/or require underline. Appropriate correction has been made herein.

<u>CLAIM OBJECTIONS</u>

Claims 12-15 were objected to on the basis of a grammatical error in the spelling of the word "reactor" in Claim 12. This present amendment obviates this matter by canceling Claim 12.

<u>REJECTION UNDER 35 U.S.C. § 102</u>

A. Claims 1-3, 12 and 14 were rejected under 35 U.S.C. § 102(b) as being anticipated by Hufton et al. ("Sorption Enhanced Reaction Process for Hydrogen Production," <u>AIChE</u>).

By the present amendment, Claim 46 replaces Claim 1, containing limitations from Claims 12 and 13, and now recites a system that comprises a water-gas shift reactor. The Hufton reference does not show a system having components as recited in Claim 46.

Claims 2, 3 and 14 now depend directly or indirectly from new Claim 46; and Claim 12 has been cancelled.

Therefore, rejection for novelty on the basis of Hufton is respectfully requested to be withdrawn.

B. Claims 1-7, 12, 14, 16-17, and 29 were rejected under 35 U.S.C. § 102(e) as being anticipated by Keefer et al. (WO 00/16425).

It is recognized in the Office Action that Keefer and all the references of record lack any teaching or suggestion of a water-gas shift reactor, which itself has an adsorbent for adsorbing carbon monoxide, as recited in allowable Claim 13. This feature having been added to new Claim 46, it is respectfully submitted that rejection of Claims 1-7, 14, 16-17, and 29, which depend directly or indirectly from new Claim 46, is now rendered moot.

<u>REJECTION UNDER 35 U.S.C. § 103</u>

A. Claims 4-7, 16-18 and 29 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Hufton et al. in view of Keefer et al.

None of the references of record, either alone or in any combination, teaches or suggests a water-gas shift reactor that includes an adsorbent to adsorb carbon monoxide. This feature, now included in Claim 46, from which the aforesaid Claims 4-7, 16-18 and 29 depend directly or indirectly, render this rejection moot.

B. Claims 8-11 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Hufton et al. in view of Kirshnamurthy (USPN 5,096,470). Claims 8-11 were also rejected under 35 U.S.C. § 103(a) as being unpatentable over Keefer et al. in view of Kirshnamurthy.

Claims 8-11 depend directly or indirectly from new Claim 46, which contains the feature of a water-gas shift reactor, which itself contains an adsorbent to adsorb carbon monoxide, such feature not being taught or suggested in any reference or

combination of references of record. Accordingly, Claims 8-11 are respectfully submitted to be patentable.

C. Claim 18 was rejected under 35 U.S.C. § 103(a) as being unpatentable over Keefer et al. as applied to an earlier rejection of Claim 1.

For the reasons described hereinabove with respect to Claim 46, from which Claim 18 depends indirectly, this rejection is rendered moot.

D. Claims 1-12, 14, 16-18, and 29 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Claims 1-43 of copending Application No. 09/780,079.

It is respectfully submitted that in view of the amendments made herein, this rejection is now rendered moot. Furthermore, it is respectfully submitted that even absent such amendments, this rejection does not have *prima facie* support in view of amendment to said copending application, wherein new independent Claims 44 and 51 thereof are clearly patentably distinct. Claims 2-11, 14, 16-18, and 29 in the present application are even further removed from said copending application on the basis of their dependence on new independent Claim 46 herein. Claim 46 recites features patentable over 09/780,079 consistent with allowable Claim 13.

DOUBLE PATENTING

Claims 1-12, 14, 16-18, and 29 were provisionally rejected the judicially-created doctrine of obviousness-type double patenting over Claims 1-43 of copending Application No. 09/780,079 on the basis that such claims recite only limitations that are recited in Claims 1-43 of said copending application.

It is respectfully submitted that this rejection is rendered moot in view of the amended status of claims in said copending application and the amended status of the claims herein. Note particularly, as explained above, that Claim 46 of the present application recites features patentable over 09/780,079 consistent with allowable Claim 13. Claims 2-11, 14, 16-18, and 29 depend on new Claim 46.

ALLOWABLE SUBJECT MATTER

A. It is acknowledged that Claims 13 and 15 would be allowable if rewritten to include all of the limitations of the base claim and any intervening claims.

Accordingly, new independent Claim 46 presented herein incorporates features from such claims for distinguishing further from the applied references as described herein with respect to Claim 46.

B. Claims 20-28 and 30 are said to be allowable.

CONCLUSION

It is respectfully submitted by this response that Claims 2-11, 14-18, 20-30, and 46-47, now pending in this application, render moot the rejections and objections of the Office Action dated August 27, 2003 and issuance of Notice of Allowance recognizing same is respectfully requested.

If the Examiner believes that personal communication will expedite prosecution of this application, the Examiner is invited to telephone the undersigned at (248) 641-1600.

Respectfully submitted,

Dated: Dec 24 2003

By: ______________________
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G:\ldescher\8540G (General Motors Corporation)\000038\Response to Notice of Non-Compliance (due 1-17-04)\Revised Amendment.doc

PATENT
Attorney Reference Number 6454-65219

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Keefer et al.
Application No. 10/286,400
Filed: November 1, 2002
Confirmation No. 3857
For: ELECTRICAL CURRENT GENERATION SYSTEM
Examiner: To be assigned
Art Unit: 1745
Attorney Reference No. 6454-65219

CERTIFICATE OF MAILING

I hereby certify that this paper and the documents referred to as being attached or enclosed herewith are being deposited with the United States Postal Service as First Class Mail in an envelope addressed to: COMMISSIONER FOR PATENTS, P.O. BOX 1450, ALEXANDRIA, VA 22313-1450 on the date shown below.

Attorney for Applicant(s) Wayne Rupert

Date Mailed October 16, 2003

COMMISSIONER FOR PATENTS
P.O. BOX 1450
ALEXANDRIA, VA 22313-1450

TRANSMITTAL LETTER

Enclosed is an Amendment for the above application. The fee has been calculated as shown below.

CLAIMS AS AMENDED						
For	No. after amendment	No. paid for previously		Present Extra	Rate	Fee
Total Claims	103	- 77*	=	26	$9.00	$ 234.00
Indep. Claims	13	- 7**	=	6	$43.00	$ 258.00
Mult. Dep. Claims Fee (if not previously paid)					$145.00	$0.00
One-month Extension of Time					$55.00	$0.00
Two-month Extension of Time					$210.00	$0.00
Three-month Extension of Time					$475.00	$0.00
TOTAL ADDITIONAL FEE FOR THIS AMENDMENT						$492.00

* greater of twenty or number for which fee has been paid.
** greater of three or number for which fee has been paid.

☒ A check in the amount of $492.00 is attached.

EXHIBIT
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☒ Please charge any additional fees that may be required in connection with filing this amendment and any extension of time, or credit any overpayment, to Deposit Account No. 02-4550. A copy of this sheet is enclosed.

☒ Please return the enclosed postcard to confirm that the items listed above have been received.

Respectfully submitted,

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cc: Docketing

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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Attorney for Applicant(s) Wayne Rupert

Date Mailed October 16, 2003

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SECOND PRELIMINARY AMENDMENT

Sir:

Please amend the above-identified application as follows:

Amendments to the Claims are reflected in the listing of claims, which begins on page 2 of this paper.

Remarks begin on page 20 of this paper.

Amendments to the Claims

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims

Claim 1 (original): An electrical current generating system comprising:

a fuel cell including an anode channel including an anode gas inlet for receiving a supply of hydrogen gas, a cathode channel including a cathode gas inlet and a cathode gas outlet, and an electrolyte in communication with the anode and cathode channel for facilitating ion exchange between the anode and cathode channel;

an oxygen gas delivery system coupled to the cathode gas inlet for delivering a gaseous stream enriched in oxygen gas to the cathode channel, the oxygen gas delivery system including a rotary pressure swing adsorption system for enriching oxygen in a gaseous feed.

Claim 2 (original): The system according to claim 1 and further comprising a first gas recirculation means coupled to the cathode gas outlet for recirculating a first portion of cathode exhaust gas exhausted from the cathode channel to the cathode gas inlet.

Claim 3 (original): The current generating system according to claim 1 where the pressure swing adsorption system includes a first feed gas inlet for receiving air feed as a first gas feed, and a gas outlet coupled to the cathode gas inlet.

Claim 4 (currently amended): The current generating system according to claim 3 where the oxygen gas delivery system includes a gas inlet for receiving a first portion of cathode gas exhausted from the cathode channel and a gas outlet for delivering the gaseous stream ~~enrich~~ <u>enriched</u> in oxygen gas to the cathode channel.

Claim 5 (original): The current generating system according to claim 4 where the oxygen gas delivery system includes a first gas recirculation means coupled to the cathode gas outlet for recirculating the first portion of cathode gas from the cathode channel to the cathode gas inlet.

Claim 6 (original): The current generating system according to claim 5, wherein the first gas recirculating means comprises a compressor for supplying the first cathode exhaust gas portion under pressure to the cathode gas inlet.

Claim 7 (original): The current generating system according to claim 6, wherein the first gas recirculation means includes a condensate separator coupled between the cathode gas outlet and the compressor for removing moisture from the first cathode exhaust gas portion.

Claim 8 (currently amended): The current generating system according to claim 6, wherein the ~~FIRST~~ first gas recirculating means directs the first cathode exhaust gas portion as feed gas to the gas separation system.

Claim 9 (original): The current generating system according to claim 4, wherein the gas separation system includes a second feed gas inlet, and the current generating system includes second gas recirculating means coupled to the cathode gas outlet for recirculating a second portion of the cathode exhaust gas to the second feed gas inlet.

Claim 10 (original): The current generating system according to claim 9 wherein the recirculating means comprises a restrictive orifice for delivering the second cathode exhaust gas portion to the gas separation system at a pressure less than a pressure of the air feed.

Claim 11 (original): The current generating system according to claim 9 where the pressure swing adsorption system comprises a rotary module including a stator and a rotor rotatable relative to the stator, the rotor including a plurality of flow paths for receiving adsorbent material therein for preferentially adsorbing a first gas component in response to increasing pressure in the flow paths relative to a second gas component, and compression machinery coupled to the rotary module for facilitating gas flow through the flow paths for separating the first gas component from the second gas component.

Claim 12 (original): The current generating system according to claim 11 wherein the plurality of flow paths are aligned with the axis of the rotor.

Claim 13 (original): The current generating system according to claim 11, wherein the stator includes a first stator valve surface, a second stator valve surface, a plurality of first function compartments opening into the first stator valve surface, and a plurality of second function compartments opening into the second stator valve surface, and the rotor includes a first rotor valve surface in communication with the second stator valve surface, and a plurality of apertures provided in the rotor valve surfaces and in communication with respective ends of the flow paths and the function compartments.

Claim 14 (original): The current generating system according to claim 13 where the compression machinery is coupled to a portion of the function compartments for maintaining the portion of function compartments at a plurality of discrete respective pressure levels between an upper pressure and a lower pressure for maintaining uniform gas flow through the portion of function compartments.

Claim 15 (original): The current generating system according to claim 13, wherein the function compartments include a light reflux exit compartment and a light reflux return compartment, the compression machinery comprises a light reflux expander coupled between the light reflux exit and return compartments, and the first gas recirculation means comprises a compressor coupled to the light reflux expander for supplying the first cathode exhaust gas portion under pressure to the cathode gas inlet

Claim 16 (original): The current generating system according to claim 15 wherein the rotary pressure swing adsorption system includes a heater disposed between the light reflux exit compartment and the light reflux expander for enhancing recovery of energy from light reflux gas exhausted from the light reflux exit compartment.

Claim 17 (original): The current generating system according to claim 15 where the function compartments include a gas feed compartment and a countercurrent blowdown compartment, and the compression machinery comprises a compressor coupled to the first feed gas inlet for delivering compressed air to the gas feed compartment, and an expander coupled to the compressor for exhausting heavy product gas enriched in the first gas component from the countercurrent blowdown compartment.

Claim 18 (original): The current generating system according to claim 15 where the function compartments include a countercurrent blowdown compartment and a heavy product compartment, and

the compression machinery comprises an expander coupled to the countercurrent blowdown compartment.

Claim 19 (original): The current generating system according to claim 18 further comprising a vacuum pump coupled to the expander for extracting heavy product gas enriched in the first gas component at subatmospheric pressure from the heavy product compartment.

Claim 20 (original): The current generating system according to claim 13 where the function compartments include a gas feed compartment, and the gas recirculating means directs the first cathode exhaust gas portion as feed gas to the gas feed compartment.

Claim 21 (original): The current generating system according to claim 13 where the function compartments include a gas feed compartment, and the current generating system includes second gas recirculating means coupled to the cathode gas outlet for recirculating a second portion of the cathode exhaust gas to the gas feed compartment.

Claim 22 (original): The current generating system according to claim 21 where the second gas recirculating means comprises a restrictor orifice.

Claim 23 (original): The current generating system according to claim 11 where the adsorbent material is one of CA-X, Li-X, lithium chabazite zeolite, calcium-exchanged chabazite and strontium-exchanged chabazite.

Claim 24 (original): The current generation system according to claim 1 where the rotary pressure swing adsorption system enriches oxygen and removes carbon dioxide from an air feed.

Claim 25 (original): The current generation system according to claim 24 further comprising a hydrogen gas delivery system coupled to the anode gas inlet.

Claim 26 (original): The current generation system according to claim 25 where the hydrogen gas delivery system enriches hydrogen gas in a gaseous feed.

Claim 27 (currently amended): The current generation system according to claim 26 further comprising an oxygen accumulator interposed between the oxygen gas delivery system and the cathode gas inlet.

Claim 28 (original): The current generation system according to claim 27 in which the electrolyte is alkaline and is maintained at a working temperature greater that about 100°C, the oxygen gas delivery system is operated to supply oxygen of about 90% purity to the cathode gas inlet, so that the product water of the fuel cell is delivered as concentrated dry steam from the cathode gas outlet; the system including a steam expander to expand the steam from the cathode gas outlet to a vacuum condenser, a condensate pump to exhaust liquid from the condenser, and a vacuum pump cooperating with the oxygen pressure swing adsorption system and exhausting permanent gas overheads from the vacuum condenser.

Claim 29 (cancelled).

Claim 30 (currently amended): The current generating system according to claim 8 where the rotary pressure swing adsorption system comprises a rotary module for implementing a pressure swing adsorption process having an operating pressure cycling between an upper pressure and a lower pressure, for extracting a first gas fraction and a second gas fraction from a gas mixture including the first and second fractions, the rotary module comprising:

a stator including a first stator valve surface, a second stator valve surface, a plurality of first function compartments opening into the first stator valve surface, and a plurality of second function compartments opening into the second stator valve surface; and

a rotor rotatably coupled to the stator and including a first rotor valve surface in communication with the first stator valve surface, a second rotor valve surface in communication with the second stator valve surface, a plurality of flow paths for receiving adsorbent material therein, each said flow path including a pair of opposite ends, and a plurality of apertures provided in the rotor valve surfaces and in communication with the flow path ends and the functions ports for cyclically exposing each said flow path to a plurality of discrete pressure levels between the upper and lower pressure for maintaining uniform gas ~~floe~~ flow through the first and second function compartments, the function compartments comprising first and second gas ~~geed~~feed compartments opening into the ~~firs~~first stator valve surface for delivering the gas mixture to the flow paths for sequentially exposing the flow paths to the second feed gas prior to the ~~firs~~first feed gas.

Claim 31 (original): The current generation system according to claim 30 where the second feed gas is enriched in oxygen relative to the first feed gas.

Claim 32 (currently amended): An electrical current generating system comprising:

a fuel cell including an anode channel including an anode gas inlet and an anode gas outlet, a cathode channel including a cathode gas inlet and a cathode gas outlet, and an electrolyte in communication with the anode and cathode channel for facilitating exchange between the anode and cathode channel;

an oxygen gas delivery system coupled to the cathode gas inlet for delivering oxygen gas to the cathode channel; and

a hydrogen gas delivery system coupled to the anode gas inlet for delivering a gaseous stream enriched in hydrogen gas to the anode channel, including a first rotary pressure swing adsorption system for enriching hydrogen in a gaseous feed.

Claims 33-36 (cancelled).

Claim 37 (original): The electrical current generating system according to claim 32 where the oxygen gas delivery system comprises an oxygen gas separation system for extracting oxygen gas from air, the gas separation system including a first feed gas inlet for receiving an air feed, and an oxygen gas outlet coupled to the cathode gas inlet for supplying enriched oxygen gas to the cathode channel from the air feed.

Claim 38 (currently amended): The electrical current generation system according to claim [[36]]32 where the oxygen gas delivery system comprises a second rotary pressure swing adsorption system for extracting oxygen gas from the air, the second rotary pressure swing adsorption system including a first feed gas inlet for receiving an air feed [[an]]and a gas outlet coupled to the cathode gas inlet for supplying a gaseous stream enriched in oxygen gas to the cathode channel.

Claims 39-44 (cancelled).

Claim 45 (currently amended): The electrical current generation system according to claim [[44]]32, where the first rotary pressure swing adsorption system includes a first gas feed inlet for receiving a first gas feed comprising hydrogen gas and a gas outlet coupled to the anode gas inlet, where the hydrogen gas delivery system comprises a reactor for producing a second hydrogen gas feed from hydrocarbon fuel, where the first rotary pressure swing adsorption system is coupled to the reactor and receives the first and second gas feeds, where the reactor comprises a steam reformer and a water gas shift reactor coupled to the steam reformer for producing the second gas feed, and where the steam reformer includes a burner including a first burner inlet coupled to the cathode gas outlet for receiving humid oxygen-enriched gas[[,]] and a second burner inlet for receiving heavy product from the first rotary pressure swing adsorption system for burning within the burner for providing endothermic heat of reaction for steam reforming the hydrocarbon fuel.

Claim 46 (cancelled).

Claim 47 (currently amended): The electrical current generating system according to claim [[46]]32, where the hydrogen gas delivery system comprises a reactor for producing a second gas feed from hydrocarbon fuel and wherein the first rotary pressure swing adsorption system is coupled to the reactor for receiving the first and second gas feeds and where the oxygen gas delivery system comprises a second rotary pressure swing adsorption system for extracting oxygen gas from air, the second rotary pressure swing adsorption system including a first feed gas inlet for receiving an air feed, and a gas outlet coupled to the cathode gas inlet for supplying a gaseous stream enriched in oxygen gas to the cathode channel, and the reactor comprises a burner including a first burner inlet for receiving air, and a second burner inlet for receiving a gaseous stream enriched in hydrogen gas from the first rotary pressure swing adsorption system for burning the received hydrogen gas within the burner for recovery of heat energy for pressurizing the air feed.

Claim 48 (original): The electrical current generating system according to claim 47 where at least one of the pressure swing adsorption systems comprises a rotary module including a stator and a rotor rotatable relative to the stator, the rotor including a plurality of flow paths for receiving adsorbent material therein for preferentially adsorbing a first gas component in response to increasing pressure in the flow paths relative to a second gas component, and compression machinery coupled to the rotary

module for facilitating gas flow through the flow paths for separating the first gas component from the second gas component.

Claim 49 (original): The current generating system according to claim 48 where the stator includes a first stator valve surface, a second stator valve surface, a plurality of first function compartments opening into the first stator valve surface, and the rotor includes a first rotor valve surface in communication with the first stator valve surface, a second rotor valve surface in communication with the second stator valve surface, and a plurality of apertures provided in the rotor valve surfaces and in communication with respective ends of the flow paths and the function compartments.

Claim 50 (original): The current generating system according to claim 49 wherein the compression machinery is coupled to a portion of the function compartments for maintaining the portion of function compartments at a plurality of discrete respective pressure levels between an upper pressure and a lower pressure for maintaining uniform gas flow through the portion of function compartments.

Claims 51-53 (cancelled).

Claim 54 (original): A method of generating an electric potential, comprising:

providing a fuel cell including an anode channel including an anode gas inlet, a cathode channel including a cathode gas inlet and a cathode gas outlet, and an electrolyte in communication with the anode and cathode channel for facilitating ion exchange between the anode and cathode channel;

supplying a gaseous stream enriched in oxygen gas to the cathode gas inlet, where the supplying step comprises supplying a first gas feed to a rotary pressure swing adsorption apparatus to produce a product gas stream enriched in oxygen gas; and

delivering the product gas stream to the cathode gas inlet.

Claim 55 (original): The method according to claim 54 and further comprising recirculating a portion of cathode gas exhausted from the cathode gas outlet to the cathode gas inlet.

Claim 56 (currently amended): The method according to claim 55 where recirculating comprises delivering the exhaust gas portion to the rotary pressure swing adsorption apparatus as a second gas ~~geed~~feed.

Claim 57 (original): The method according to claim 56 where the recirculating further comprises purging a remainder of the exhausted cathode gas.

Claim 58 (original): The method according to claim 57 where recirculating comprises delivering the exhaust gas portion at increased pressure to the cathode gas inlet.

Claim 59 (original): The method according to claim 58 where recirculating further comprises recovering waste heat from the fuel cell for enhancing recovery of expansion energy from the pressure swing adsorption apparatus.

Claim 60 (original): The method according to claim 54 where supplying hydrogen gas comprises recirculating a portion of cathode gas exhausted from the cathode gas outlet to the inlet of a fuel processor for reacting a hydrocarbon fuel to generate hydrogen.

Claim 61 (original): A method for generating electrical potential, comprising:

providing a fuel cell including an anode channel including an anode gas inlet, a cathode channel including a cathode gas inlet and a cathode gas outlet, and an electrolyte in communication with the anode and cathode channel for facilitating ion exchange between the anode and cathode channel;

supplying a first gaseous stream enriched in hydrogen gas to the anode gas inlet, where supplying comprises supplying a first gas feed to a rotary hydrogen pressure swing adsorption apparatus to produce a first product gas stream enriched in hydrogen gas;

delivering the first product gas stream to the anode gas inlet; and

supplying a second gaseous stream enriched in oxygen gas to the cathode gas inlet.

Claim 62 (original): The method according to claim 61 and further comprising recirculating a portion of anode gas exhausted from the anode gas outlet to the anode gas inlet.

Claim 63 (original): The method according to claim 62 where recirculating comprises delivering the exhaust gas portion to the rotary hydrogen pressure swing adsorption apparatus as a second gas feed.

Claim 64 (original): The method according to claim 63 where supplying a second gaseous stream comprises supplying an air feed to a rotary oxygen pressure swing adsorption apparatus to produce a second product gas stream enriched in oxygen gas, and delivering the second product gas stream to the cathode gas inlet.

Claim 65 (currently amended): The method according to claim ~~64where~~64 where supplying hydrogen gas comprises supplying a hydrocarbon fuel to a reformer, reacting the fuel with oxygen-enriched gas from the cathode gas outlet, delivering a hydrogen gas feed from the reformer as a first gas feed to a hydrogen pressure swing adsorption apparatus, and delivering hydrogen-enriched gas extracted from the first gas feed as light product gas to the anode gas inlet.

Claim 66 (original): The method according to claim 65 where the reformer comprises a steam reformer including a combustor, and reacting comprises delivering the fuel to the combustor, and providing heat energy to the combustor by burning tail gas extracted from the rotary hydrogen pressure swing adsorption apparatus as heavy product gas with the oxygen-enriched gas from the cathode gas outlet in the combustor.

Claim 67 (original): The method according to claim 65 where the reformer comprises a steam reformer including a combustor, and reacting comprises delivering the fuel to the combustor, and providing heat energy to the combustor by burning tail gas extracted from the rotary hydrogen pressure swing adsorption apparatus as heavy product gas with a portion of the air feed in the combustor, and recovering heat of combustion from the combustor for delivering air under pressure to the rotary oxygen pressure swing adsorption apparatus.

Claim 68 (original): The method according to claim 65 where the reformer comprises an autothermal reformer including a water gas shift reactor, and the step of supplying a pressurized air feed comprises the steps of delivering air to a combustor, burning tail gas extracted from the hydrogen pressure swing adsorption apparatus as heavy product gas with the delivered air in the combustor, and recovering heat of combustion from the combustor for delivering air under pressure to the oxygen pressure swing adsorption apparatus.

Claim 69 (original): An electrical current generating system comprising:

a fuel cell including an anode channel including an anode gas inlet and an anode gas outlet, a cathode channel including a cathode gas inlet and a cathode gas outlet, and an electrolyte in communication with the anode and cathode channel for facilitating ion exchange between the anode and cathode channel;

an oxygen gas delivery system coupled to the cathode gas inlet for delivering enriched oxygen gas to the cathode channel, the oxygen gas delivery system including a pressure swing adsorption system to enrich oxygen and to remove carbon dioxide from atmospheric air feed; and

a hydrogen gas delivery system coupled to the anode gas inlet for delivering purified hydrogen gas to the cathode channel.

Claim 70 (currently amended): The current generating system according to claim 69 further including an oxygen accumulator interposed between the oxygen gas delivery system and the cathode gas inlet. ~~The method according to claim 65 where the reformer comprises a steam reformer including a combustor, and reacting comprises delivering the fuel to the combustor, and providing heat energy to the combustor by burning tail gas extracted from the hydrogen pressure swing adsorption apparatus as heavy product gas with the oxygen-enriched gas from the cathode gas outlet in the combustor.~~

Claim 71 (original): The electrical current generation system according to claim 1 where the rotary pressure swing adsorption system comprises a plurality of adsorbers having first and second ends communicating respectively to a first valve face and a second valve face, the plurality of adsorbers being housed in an adsorber housing body cooperating with first and second valve bodies respectively sealingly engaged with the adsorber housing body at the first and second valve faces.

Claim 72 (original): The electrical current generation system according to claim 71 where the adsorber housing body rotates relative to the first and second valve bodies.

Claim 73 (original): The electrical current generation system according to claim 71 where the first and second valve bodies rotate relative to the adsorber housing.

Claim 74 (original): The electrical current generation system according to claim 73 where the rotary pressure swing adsorption system further comprises transfer chambers providing fluid

communication between the first valve body and respectively a feed air inlet conduit and an exhaust discharge conduit.

Claim 75 (original): The electrical current generation system according to claim 73 where the rotary pressure swing adsorption system further comprises a transfer chamber providing fluid communication between the second valve body and the product oxygen conduit to the cathode inlet.

Claim 76 (original): The electrical current generation system according to claim 1 further where the pressure swing adsorption system generates a gaseous stream enriched in oxygen, the gaseous stream enriched in oxygen having a first oxygen purity and being fluidly coupled to the cathode gas inlet, the system further comprising a compressed air inlet for mixing compressed air with the gaseous stream enriched in oxygen upstream of the cathode gas inlet, thereby forming a cathode feed gas stream having a second oxygen purity lower than the first oxygen purity.

Claim 77 (currently amended): The electrical current generation system according to claim 76 where the first oxygen purity is in the range of from about 70% to about 90% and the second oxygen purity is in the range of from about 30% to about 40%.

Claim 78 (new): An electrical current generating system, comprising:

at least one fuel cell; and

a hydrogen gas delivery system coupled to the fuel cell for delivering hydrogen to the fuel cell, the hydrogen gas delivery system comprising a rotary pressure swing adsorption module.

Claim 79 (new): The system according to claim 78, wherein the rotary pressure swing adsorption module comprises a rotary module including a stator and a rotor rotatable relative to the stator, the rotor including a plurality of flow paths for receiving adsorbent material therein for preferentially adsorbing a first gas component of a hydrogen-containing gas.

Claim 80 (new): The system according to claim 78, wherein the hydrogen gas delivery system comprises a reactor for producing a hydrogen gas feed from a hydrocarbon fuel, and the rotary pressure swing adsorption module is coupled to the reactor and receives the hydrogen gas feed.

Claim 81 (new): The system according to claim 80, wherein the reactor comprises a steam reformer that includes a burner having an inlet for receiving heavy product from the rotary pressure swing adsorption module for burning within the burner.

Claim 82 (new): An electrical current generating system, comprising:

at least one fuel cell defining an anode inlet and an anode outlet; and

a hydrogen gas separation device coupled to the fuel cell anode inlet for delivering enriched hydrogen to the fuel cell anode, the hydrogen gas separation device receiving a recycle gas from the fuel cell anode outlet and a hydrogen feed gas from a hydrogen gas generating system.

Claim 83 (new): The system according to claim 82, wherein the hydrogen gas generating system comprises a reformer reactor or a partial oxidation reactor.

Claim 84 (new): The system according to claim 82, wherein the hydrogen gas separation device comprises an adsorption device.

Claim 85 (new): The system according to claim 84, wherein the adsorption device comprises a rotary pressure swing adsorption module.

Claim 86 (new): The system according to claim 82, wherein the hydrogen gas separation device comprises a first inlet for receiving the recycle gas from the fuel cell anode outlet and a second inlet for receiving the hydrogen feed gas from a hydrogen gas generating system.

Claim 87 (new): The system according to claim 84, wherein the electrical current generating system further comprises a system for recirculating a heavy product exhaust gas through the adsorption device.

Claim 88 (new): An electrical current generating system, comprising:

at least one fuel cell defining an anode inlet, an anode outlet, and a cathode inlet;

an oxygen gas delivery system coupled to the cathode inlet for delivering oxygen gas to the fuel cell cathode; and

a hydrogen gas separation device coupled to the fuel cell anode inlet for delivering enriched hydrogen to the fuel cell anode, wherein the hydrogen gas separation device receives a recycle gas from the fuel cell anode outlet and a hydrogen feed gas from a hydrogen gas generating system.

Claim 89 (new): The system according to claim 88, wherein the hydrogen gas generating system comprises a reformer reactor or a partial oxidation reactor.

Claim 90 (new): The system according to claim 88, wherein the hydrogen gas separation device comprises an adsorption device.

Claim 91 (new) The system according to claim 90, wherein the adsorption device comprises a rotary pressure swing adsorption module.

Claim 92 (new): The system according to claim 88, wherein the hydrogen gas separation device comprises a first inlet for receiving the recycle gas from the fuel cell anode outlet and a second inlet for receiving the hydrogen feed gas from a hydrogen gas generating system.

Claim 93 (new): The system according to claim 90, wherein the electrical current generating system further comprises a system for recirculating a heavy product exhaust gas through the adsorption device.

Claim 94 (new): The system according to claim 88, wherein the hydrogen gas separation device preferentially separates at least one carbon oxide from the recycle gas and the hydrogen feed gas.

Claim 95 (new): A process for providing hydrogen gas to a fuel cell, comprising:

providing a rotary pressure swing adsorption module that can produce a purified hydrogen-containing gas; and

introducing the purified hydrogen-containing gas into a fuel cell.

Claim 96 (new): The process according to claim 95, further comprising introducing a hydrogen-containing feed gas into the rotary pressure swing adsorption module, wherein the hydrogen-containing feed gas is generated by reforming or partial oxidation.

Claim 97 (new): The process according to claim 96, further comprising heating the reforming or partial oxidation reaction by utilizing the combustion energy of a heavy product exhaust gas produced by the rotary pressure swing adsorption module

Claim 98 (new): A process for providing hydrogen gas to a fuel cell, comprising:

providing a hydrogen gas separation module for delivering purified hydrogen-containing gas stream to a fuel cell;

introducing a fuel cell effluent into the hydrogen gas separation module as a first hydrogen-containing gas feed stream; and

introducing a second hydrogen-containing gas feed stream into the hydrogen gas separation module.

Claim 99 (new): A process for providing hydrogen gas and oxygen gas to a fuel cell, comprising:

introducing an oxygen gas stream to a fuel cell cathode;

providing a hydrogen gas separation module for delivering purified hydrogen gas stream to a fuel cell anode;

introducing a fuel cell effluent into the hydrogen gas separation module as a first hydrogen gas feed stream; and

introducing a second hydrogen gas feed stream into the hydrogen gas separation module.

Claim 100 (new): The process according to claim 99, wherein the hydrogen gas separation module comprises a pressure swing adsorption module.

Claim 101 (new): The process according to claim 99, wherein the hydrogen gas separation module removes at least a portion of at least one carbon oxide component from at least one of the first hydrogen gas feed stream or the second hydrogen gas feed stream.

Claim 102 (new): The process according to claim 101, comprising removing a substantial amount of carbon dioxide present in the first hydrogen-containing gas feed stream.

Claim 103 (new): The process according to claim 101, wherein the carbon oxide is carbon monoxide or carbon dioxide.

Claim 104 (new): An electrical current generating system, comprising:

at least one fuel cell;

a hydrogen gas delivery system coupled to the fuel cell, the hydrogen gas delivery system including a hydrogen gas generating reactor; and

an oxygen gas delivery system coupled to the fuel cell, the oxygen gas delivery system including at least one air compressor for delivering a first air stream to the oxygen gas delivery system and a second air stream to the hydrogen gas delivery system.

Claim 105 (new): An electrical current generating system, comprising:

at least one fuel cell;

a hydrogen gas delivery system coupled to the fuel cell;

an oxygen gas delivery system coupled to the fuel cell; and

a gas turbine system coupled to at least one of the hydrogen gas delivery system or oxygen gas delivery system.

Claim 106 (new): The system according to claim 105, wherein the hydrogen gas delivery system includes a combustion device exhausting a combustion gas, and the gas turbine system is coupled to the combustion device for receiving the combustion gas as a working fluid for driving the hydrogen gas delivery system or the oxygen gas delivery system.

Claim 107 (new): The system according to claim 106, wherein the combustion device comprises at least one burner defining an outlet for the combustion gas, and the gas turbine system comprises at least one expander having an inlet fluidly communicating with the burner outlet for receiving the combustion gas and at least one compressor or vacuum pump coupled to the expander.

Claim 108 (new): The system according to claim 106, wherein the hydrogen gas delivery system includes a pressure swing adsorption module that can produce a heavy product exhaust gas stream for delivery to the combustion device.

Claim 109 (new): The electrical current generating system of claim 80, wherein the rotary pressure swing adsorption module comprises a contaminant-selective adsorbent for adsorbing a contaminant from the hydrogen gas feed.

Claim 110 (new): The electrical current generating system of claim 109, wherein the contaminant is selected from at least one of carbon dioxide, carbon monoxide, nitrogen, ammonia, hydrogen sulfide, methanol, chlorine, and water.

Claim 111 (new): The process according to claim 96, wherein the hydrogen-containing feed gas includes at least one contaminant and the rotary pressure swing adsorption module includes an adsorbent that preferentially adsorbs the contaminant.

Claim 112 (new): The process according to claim 111, wherein the contaminant is selected from at least one of carbon dioxide, carbon monoxide, nitrogen, ammonia, hydrogen sulfide, methanol, chlorine, and water.

Claim 113 (new): The system according to claim 32, wherein the hydrogen gas delivery system comprises a reactor for producing a gas feed from hydrocarbon fuel, the first rotary pressure swing adsorption system is coupled to the reactor for receiving the gas feed, and the first rotary pressure swing adsorption system comprises a contaminant-selective adsorbent for adsorbing a contaminant from the hydrogen gas feed.

Claim 114 (new): The system according to claim 113, wherein the contaminant is selected from at least one of carbon dioxide, carbon monoxide, nitrogen, ammonia, hydrogen sulfide, methanol, chlorine, and water.

Claim 115 (new): The system according to claim 1, wherein the rotary pressure swing adsorption system operates at an elevated temperature.

Claim 116 (new): The system according to claim 1, wherein the rotary pressure swing adsorption system operates at a temperature greater than ambient temperature.

Claim 117 (new): The system according to claim 1, wherein the rotary pressure swing adsorption system operates at a temperature of about 40°C to about 60°C.

Claim 118 (new): The system according to claim 1, wherein the rotary pressure swing adsorption system operates at a temperature greater than 100°C.

Remarks

After entry of this amendment claims 1-32, 37-38, 45, 47-50, and 54-118 should be pending. Claims 33-36, 39-44, 46, and 51-53 have been cancelled. Claims 27, 30, 38, 45, 47, 56, 65, and 77 have been amended to correct typographical errors present in the application as filed and/or to eliminate their dependency on cancelled claims. New claims 78-118 have been added. Entry of the cancellations, amendments and additions is respectfully requested. Support for claims 78-118 is found in the specification as follows:

Claims 78 and 95 – Page 6, lines 14-19 and page 20, lines 16-17.

Claim 79 – Page 6, lines 18-22.

Claim 80 - Page 6, lines 14-18.

Claim 81 – Page 6, lines 27-31.

Claims 82, 84-86, 88, 90-92 and 98-100 – Page 6, lines 10-19; and elements 10, 436, and 438 of Figure 12.

Claims 83, 89 and 96 – Page 2, lines 13-17, and page 45, lines 3-7.

Claims 87 and 93 – Page 21, lines 22-25.

Claims 94 and 101-103 – Page 8, lines 22-27, and page 44, line 30 – page 45, line 15.

Claim 97 – Page 6, line 29 – page 7, line 1.

Claim 104 – Page 7, lines 6-8.

Claims 105-107 – Page 7, lines 9-11, page 32, lines 18-22, and elements 548, 552, 550, 546, and 523 of Figure 13.

Claim 108 – Page 20, lines 27-29, Page 32, lines 20-22, and elements 550, 546, and 523 of Figure 13.

Claims 109-114 – Page 20, lines 16–24 and page 44, line 20 – page 45, line 11.

Claims 115-118 – Page 23, lines 22-27.

Conclusion

A first preliminary amendment was mailed on November 1, 2002. Applicants look forward to receiving a first action on the merits.

Respectfully submitted,

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54. Title of Invention: Method of Recovering CO_2 and H_2 from Converter Gas

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SPECIFICATION

1. TITLE OF INVENTION

Method of Recovering CO_2 and H_2 from Converter Gas

2. WHAT IS CLAIMED IS:

A method of recovering CO_2 and H_2 from converter gas in which converter gas is modified, and then the CO_2 in the modified gas is absorbed in an absorption tower and CO_2 is obtained from the absorption solution, and then the absorption tower offgas is pressurized and the pressurized gas is treated by a PSA (pressure swing adsorber), wherein PSA offgas is additionally treated by a PSA installed in series and then supplied to a fuel cell, with electricity obtained and the fuel cell completely combusting the offgas, and the combustion heat is converted to steam and utilized.

3. DETAILED DESCRIPTION OF THE INVENTION

[Industrial Field Of Application]

The present invention pertains to a method of recovering CO_2 and H_2 from converter gas generated from an LD converter, etc. when making steel and obtaining heat and electrical energy.

[Prior Art]

In recent years, LD converters, etc. used for making steel have sought to actively recover and effectively utilize the converter exhaust gas, which contains CO, CO_2, and H_2 generated during operations.

These converter gas components, on a volume standard (hereinafter the same) are CO_2 10~15%, H_2 1%, CO 65~75%, N_2 10%, and O_2 1%.

This converter gas itself can be used as fuel gas, but sometimes a recovery method is performed in which this gas is used as a raw-material gas, with steam added to it to cause a shift reaction that makes carbon dioxide and hydrogen; this increases the added value.

FIG. 2 is a process diagram of the conventional method of recovering CO_2 and H_2 from LD converter gas.

In the drawing, LD converter gas with the aforesaid composition is used as a raw material and passes through a modification step in which this gas is pressurized to 9~20 kg/cm^2, steam is added to it, a shift reaction is caused, and the gas components are modified. (More than this is not shown in the drawing.)

Next, the modified gas is introduced to an absorption tower 1, the CO_2 in the modified gas is absorbed in the potassium carbonate solution (K_2CO_3) that is the absorption solution and makes potassium bicarbonate ($KHCO_3$); this is stripped with steam and the absorption solution becomes K_2CO_3 while the stripped CO_2 gas is made into a product.

The CO_2 is discharged, and the H_2-rich offgas in the absorption tower 1 has its pressure increased from 9~20 kg/cm^2 to 9~25 kg/cm^2 by a PSA compressor 2, and is treated by a PSA (Pressure Swing Adsorption device) 3. Gases other than hydrogen are adsorbed in the PSA by utilizing the pressure differential, and separated into product high-

purity hydrogen (PH_2) and offgas (RH_2). The offgas is stored in an HR_2 holder 4, and is exhausted as fuel for another process by a blower 5.

An example of the components of the offgas in this case are CO_2 12%, H_2 58%, CO 3.5%, N_2 26%, and O_2 0.5%.

[Problems the Invention Is to Solve]

As noted above, even though offgas in the conventional recovery method for recovering CO_2 and H_2 from converter gas contains about 60% H_2, it is merely to be used for fuel.

Hospitals, offices, etc. in the vicinity of a steel plant need steam, electricity, hot water, heating and cooling facilities, etc. Currently, as described previously, even though the CO_2, H_2, etc. recovered from converter gas are a beneficial energy source, there are many cases in which the demand of the aforesaid sort of public welfare and management facilities is met by purchased electricity, and heavy oil, etc. is used for hot water and heating and cooling.

The object of the present invention is to provide a method of efficiently recovering CO_2 and H_2 from converter gas that is relatively low in calories (500~1700 $Kcal/Nm^3$) for manufacturing equipment but high in hydrogen concentration, and of efficiently utilizing the energy contained therein.

[Means for Solving the Problems]

The present inventors focused on PSA offgas, which contains about 60% hydrogen in the conventional method, studied efficient utilization of this offgas, and arrived at the present invention. That is, the present invention is a method of separating and recovering H_2 from converter gas in which converter gas is modified, and then the CO_2 component in the modified gas is absorbed in K_2CO_3 solution in an absorption tower and product CO_2 is obtained from the absorption solution, and then the absorption waste gas is pressurized and the pressurized gas is treated by a PSA; it is characterized in that PSA offgas is additionally treated by a PSA installed in series and then the gas (a gas with little CO component and a high-concentration H_2 component)

is supplied to a fuel cell, electricity is obtained, the fuel cell completely combusts the offgas, and the combustion heat is converted to steam and utilized.

[Operation]

In the inventive method of recovering CO_2 and H_2 from converter gas the PSA offgas, which contains about 60% hydrogen, is additionally treated by a PSA installed in series, and it is possible to efficiently recover high-concentration H_2 with a low CO component, so it is possible to supply it as fuel gas for a fuel cell.

Furthermore, the fuel cell completely combusts the offgas and its exhaust heat can be recovered as steam, so it is possible to advantageously recover in a cost-effective manner various types of energy—electricity, steam, fuel gas, etc.—all at once.

Next, embodiments shall be described.

[Embodiments]

FIG. 1 is a process explanatory diagram for inventive method of recovering CO_2 and H_2 from converter gas.

In FIG. 1, 1~4 are the same as in the aforesaid FIG. 2, so explanation thereof is omitted.

Item 6 is a PSA installed in series, 7 is a vacuum blower, 8 is a blower, 9 is a valve, 10 is a heat exchanger, 11 is an air blower for a combustion, 12 is a fuel cell, 13 is a hydrogen electrode chamber (negative electrode), 14 is an oxygen electrode chamber (positive electrode), 15 is electrolyte, 16 is a pump, 17 is a preheater, 18 is a combustor, 19 is a boiler, and 20 is a chimney.

The inventive method shall be described based on FIG. 1.

The raw-material gas was LD converter gas (H_2: 0.7%, CO: 69.8%, CO_2: 14.7%, N_2: 14.3%) at 1.298 Nm^3/H. This gas was pressurized to 9~11 kg/cm^2 by a compressor, and then this gas was modified to hydrogen through a shift reaction using steam, and then the CO_2 in the gas was absorbed in K_2CO_3 solution, the absorption solution was stripped with steam, and product CO_2 was obtained. Next, the absorption tower 1's offgas was pressurized to 16 kg/cm^2 by the PSA

compressor 2, and treated by the PSA 3.

In the PSA 3, gases other than H_2 were adsorbed by adsorbent in the tower, and [the offgas] was separated into product H_2 and offgas RH_2 containing gases other than H_2.

The offgas RH_2 was temporarily stored in a holder 4, and by controlling a valve 9 was treated at the next PSA 6 by a suitable blower 8 (2000 nm water column).

The treated hydrogen gas from the PSA 6 (553 Nm^3/H) was treated by the PSA 6, so it contains H_2 89.5%, CO 1.1%, CO_2 0.4%, and N_2 9%; it is something that can be supplied to a fuel cell.

Next, an embodiment for recovering electricity and steam from the fuel cell shall be described.

The treated hydrogen gas from the aforesaid PSA 6 was sucked in by the vacuum blower 7, and at the heat exchanger 10, the offgas temperature was heat-exchanged with waste gas after recovering combustion exhaust heat from the fuel cell 12's offgas and raised to 90°C, and introduced to the hydrogen electrode (negative electrode) of the fuel cell 12.

Meanwhile, air 2000 nm^3/H was supplied to the heat exchanger 10 by the blower 11 and heated to 120°C; this air was introduced to the fuel cell 12's oxygen electrode 14.

The fuel cell 12 uses an aqueous phosphoric acid solution 15 as its electrolyte, and has two electrodes made of platinum and ruthenium surrounding this.

At the negative electrode (hydrogen electrode 13), the introduced oxygen gas passes through tiny holes in the electrode, comes close to the reaction zone, is adsorbed by catalyst added to the electrode, and becomes active atomic hydrogen. This atomic hydrogen reacts with hydroxide ions in the electrolyte as in the following equation and becomes water, and when doing so transports two electrons to the electrode.

$$H_2 + 2OH^- \rightarrow 2H_2O + 2e^-$$

At the positive electrode (oxygen electrode 14), the two electrons from the electrode are received, based on the presence of the catalyst, and oxygen molecules in the air supplied from outside react with water from the electrolyte and generate a hydrogen peroxide ion and a hydroxide ion as

in the following equation. The hydrogen peroxide ion comes into contact with the catalyst and breaks down and forms a hydroxide ion and oxygen. This oxygen is utilized in the electrode reaction once again. Therefore, the positive electrode reaction is:

$$1/2\ O_2 + H_2O + 2e^- \rightarrow 2OH^-$$

The hydroxide ions generated by this positive electrode 14 are transported in the electrolyte 15 and reach the negative electrode 13. This formed an entire circuit and produced 740 KW of electricity.

The 190°C offgasses from both the negative electrode 13 and positive electrode 14 of the fuel cell were introduced to the combustor 18 and completely combusted. The 430°C combustion exhaust gas [was supplied to] the boiler 19, where its waste heat was recovered and 6 kg/cm^2 of saturated steam 0.7T/H was recovered.

Furthermore, a preheater 17 for pure water was provided inside the negative electrode 13's chamber, and after preheating [this water] was supplied to the boiler 19.

The boiler 19's offgas [was supplied to] the heat exchanger 10 and [used to] preheat the gas supplied to the fuel cell and air as described earlier and then vented from a chimney 20.

As a result, the value of converter gas was increased 1.86 times compared to the conventional method.

[Effect of the Invention]

The following sorts of effects are achieved by the inventive method of recovering CO_2 and H_2 from converter gas.

(1) Electricity, steam, fuel gas, etc. can be obtained all at once from offgas from converter gas purification equipment, and it is possible to give converter gas higher added value.

(2) It is possible to respond to a varied demand for electricity, steam, fuel gas, etc., so one can rationalize the facilities in the vicinity of a steel mill.

4. BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a process explanatory drawing for the inventive method. FIG. 2 is a process explanatory drawing for the conventional method.

In the drawings, 1 is an absorption tower, 2 is a PSA compressor, 3 is a PSA, 4 is a RH_2 holder, 6 is a PSA (offgas treatment), 7 is a vacuum blower, 8 is a blower, 9 is a valve, 10 is a heat exchanger, 11 is an air blower, 12 is a fuel cell, 13 is a negative electrode (hydrogen electrode), 14 is a positive electrode (oxygen electrode), 15 is electrolyte, 17 is a preheater, 18 is a combustor, and 19 is a boiler.

Furthermore, codes that are the same in both drawings indicate equivalent parts.

Agent: Masatoshi Sato, Patent Agent

FIG. 1

1: Absorption tower

2: PSA compressor

3: PSA

4: RH_2 holder

5: Blower

6: PSA (offgas treatment)

7: Vacuum blower

8: Blower

9: Valve

10: Heat exchanger

11: Air blower

12: Fuel cell

13: Negative electrode (hydrogen electrode)

14: Positive electrode (oxygen electrode)

15: Electrolyte

16: Pump

17: Preheater

18: Combustor

19: Boiler

20: Chimney

FIG. 2

* * *

While all translations are carefully prepared and reviewed, please note that liability for incidental or consequential damages occasioned by omissions, additions, or differences of interpretation shall not exceed the translation fee.